SUBMERSED AQUATIC VASCULAR PLANTS IN ICE-COVERED PONDS OF CENTRAL OHIO

RONALD L. STUCKEY, JOHN R. WEHRMEISTER,
& ROBERT J. BARTOLOTTA

Few observations of submersed aquatic vascular plants persisting in vegetative condition during the winter season in northern temperate regions have been recorded in the standard references on aquatic plants written in the English language (Arber, 1920; Fassett, 1940; Muenscher, 1944; Sculthorpe, 1967; Hutchinson, 1975). Recently, Boylen and Sheldon (1976) called attention to certain growth phenomena of leafy aquatic plants in water under ice cover. Our observations were made on plants in small, shallow, man-made ponds during the severe winter of 1976–1977, when ambient air temperatures remained below freezing continuously from 28 December to 2 February and below 10° C (50° F) until 22 February. Our observations confirm the perennial growth habits of six species which overwintered as submersed, whole, intact leafy plants. The species studied were *Najas guadalupensis, Potamogeton crispus, Ceratophyllum demersum, Elodea canadensis, Myriophyllum spicatum,* and *Ranunculus longirostris.*

Field observations were made on these species in three ponds (1, 1B and 16) in the Delaware Reservoir Wildlife Area, Delaware County, about 67 kilometers (42 miles) north of Columbus, between U.S. Routes 23 and 42. In the area, approximately 50 ponds were constructed by damming small streams or waterways in the period 1953–1955 (Ross, 1974). Since then various species of submersed aquatic vascular plants have become established. The ponds studied have varying depths with a maximum of 1 to 2 meters, mud bottoms, and are surrounded by shore vegetation of willows, elms, maples, cottonwoods, and cat-tails. Locations of populations of aquatic plants in the ponds were marked with metal stakes in the fall of 1976 to locate the populations during the winter season. Ice cover developed to 30 centimeters with a maximum snow cover of 12.5 centimeters over the ice at the time of measurement. Water temperatures under the ice ranged from 1° C to 4° C (34° F to 39° F). Incident radiation penetrating the snow and ice cover was measured with a Protomatic Underwater Photometer as described by Rich and Wetzel (1969). As measured 25 February 1977, on a hazy sunny

day, light intensity directly beneath the ice was 120 foot candles and at the bottom of the pond at 1.5 meters, light was at 1 foot candle. Above the pond, light intensity was 1300 foot candles. On a cloudy day, light intensity was reduced to 29 foot candles directly below the ice and less than 1 foot candle at the bottom of the pond. Depth of occurrence of the aquatic plants was approximately 0.5 to 1.5 meters. The populations were sampled on 22 January, 12 February, and 25 February, and were followed with frequent observations during the spring season. To ascertain during the winter season whether the plants were indeed alive and physiologically active, all of the above-cited species were transplanted into ten-gallon aquaria maintained at room temperature, approximately 18° C (65° F). All of the species showed continued elongation of stems and the formation of new leaves, with the exception of *Ranunculus longirostris.* To reveal the vegetative condition of the plants as they existed under natural conditions during the winter season and the new growth in the spring season, voucher specimens were prepared and deposited in the herbaria at The Ohio State University (OS) and University of Michigan (MICH).

In most of the standard references on aquatic plants and in the more general manuals of the temperate flora, the winter growth habit of aquatic vascular plants is either not noted or authors are in disagreement as to the overwintering conditions. Our observations of these six species under the ice during the winter season confirm that they persisted as whole plants in a vegetative state. The plants had stems with cauline leaves and, with the exception of *Ceratophyllum demersum,* these leaves or leaf segments were smaller in width than usually occurs in the summer foliage.

COMMENTARY ON SPECIES STUDIED

Najas guadalupensis (Spreng.) Magnus

Fernald (1950) and Lawrence (1951) state that the genus *Najas* consists of herbaceous annuals. However, Rosendahl (1939) noted that *N. olivacea* overwintered as a perennial vegetative plant. In agreement with Rosendahl, Sculthorpe (1967, p. 347) considered all members of the genus to be annuals, with the exception of *N. olivacea.* In a comprehensive study of life forms of Indiana vascular plants, McDonald (1937) listed *N. guadalupensis* as an annual.

A large colony of this species has been observed by the first author in Pond 1B every summer and fall since 1968. It had been speculated that the plants in this colony were perennial. During the 1976–1977 winter season we repeatedly observed whole intact vegetative plants. In the spring, new shoots emerged from the persisting stem apices confirming the perennial habit of this species in central Ohio. The growth phenomena observed on these plants are very similar to that reported for *Najas olivacea* by Rosendahl (1939) who noted that the plant "renews freely from the persistent lower portions of stems of the previous season."

Potamogeton crispus L.

Butcher (1933) and Gessner (1959, p. 300) state that the vegetative plant body "dies down" with the onset of winter. In discussing the overwintering of this species, Sculthorpe (1967, pp. 348–349), Harmon (1974), and Hutchinson (1975, p. 236) do not allow for the possibility that the species may overwinter as a vegetative plant body. Our observations confirm those of Moore (1915, p. 264), Glück (1924, pp. 120–123), and Waisel (1971), who described the winter vegetative form of *Potamogeton crispus*. The leaves of the winter form are flat, blue-green, and narrow in contrast to the undulate, reddish-brown, wider leaves of the summer form.

Ceratophyllum demersum L.

This species is usually considered to overwinter by means of densely crowded dormant stem apices as discussed by Pearl (1907), Arber (1920, p. 216), Evermann and Clark (1920, pp. 165, 302), Glück (1924, pp. 133–134), Muenscher (1944, p. 228), and Sculthorpe (1967, p. 346). With the exception of Sculthorpe, these authors also mention that *Ceratophyllum demersum* may overwinter as an intact vegetative plant body. Muenscher (1944, p. 228) states that "In deep water vegetative plants may be found throughout the winter even under ice." Although the plants in Pond 1 occurred in shallow water, our observations confirm the report of Muenscher, as well as those cited above.

Elodea canadensis Michx.

Sculthorpe (1967, p. 346) describes this species as perennating by densely crowded apices. Our observations were that *Elodea canadensis* remained as a leafy green plant throughout the winter confirming similar statements by Evermann and Clark (1920, pp. 122, 174).

Myriophyllum spicatum L.

Most of the general reference works on aquatic plants report that species of *Myriophyllum* overwinter by the formation of turions or winter buds. With considerable confusion existing among the morphological characters used to separate the non-indigenous *M. spicatum* from the native *M. exalbescens,* it is difficult to ascertain which descriptions of overwintering structures are applicable to *M. spicatum.* Our observations confirm those of Evermann and Clark (1920, pp. 196, 374–375), Glück (1924, p. 102), and Stanley *et al.* (1976) who indicate that entire plants overwinter.

Ranunculus longirostris Godr.

Our observations coincide with those of Goebel (1892, pp. 354–355), Evermann and Clark (1920, pp. 187, 313), and Glück (1924, p. 230), who report that this species overwinters in the form of leafy green plants. However, in the spring the leafy portions of these plants disappeared from the population we studied during the winter. This species has been observed regularly by the first author in Pond 1 during September for the past several years, and its absence at this time may be temporary suggesting that additional study is necessary on its life history. The plants from this population did not initiate new growth when transplanted into aquaria in the laboratory during the winter season.

SUMMARY AND CONCLUSIONS

The presently accepted life histories of many submersed aquatic vascular plants, which assume perennation exclusively by various types of specially formed dormant structures, deserve reevaluation. It may mean that an additional slow-growing or dormant phase in the vegetative condition could appropriately be integrated into our present concepts of the life histories of many of these species. In addition, the success of several of the above-cited species as "weedy" invaders or as aggressive competitors may be correlated with their ability to remain in a vegetative condition throughout the winter season. With the onset of melting ice, such plants are already active photosynthetically and occupy considerable area in the habitat long before the germination of the seeds of annuals or the development of foliage of species perennating from rhizomes.

LITERATURE CITED

ARBER, AGNES. 1920. Water plants: A study of aquatic angiosperms. University Press, Cambridge. 436 pp. (Reprinted with Introduction, pp. I–XII, by William T. Stearn. J. Cramer, Weinheim. Historiae Naturalis Classica Tomus XXIII. 1963, 1972.)

BOYLEN, CHARLES W., & RICHARD B. SHELDON. 1976. Submergent macrophytes: Growth under winter ice cover. Science **194:** 841, 842.

BUTCHER, R. W. 1933. Studies on the ecology of rivers. Jour. Ecology **21:** 58–127.

EVERMANN, BARTON WARREN, & HOWARD WALTON CLARK. 1920. Lake Maxinkuckee: A physical and biological survey. Vol. II. The Department of Conservation. Indianapolis, Indiana. 512 pp.

FASSETT, NORMAN C. 1940. A manual of aquatic plants. McGraw Hill Book Co., New York. 382 pp. (Reprinted with Revision Appendix by Eugene C. Ogden. University of Wisconsin Press, Madison. 405 pp. 1957.)

FERNALD, MERRITT LYNDON. 1950. Gray's manual of botany. 8th Ed. American Book Co., New York. 1xiv + 1632 pp. (Reprinted by D. Van Nostrand Co., New York. 1970.)

GESSNER, F. 1959. Hydrobotanik: Die Physiologischen Grundlagen der Pflanzenverbreitung in Wasser. Vol. II. Stoffhaushalt. VEB Deutscher Verlag der Wissenschaften, Berlin. 517 pp.

GLÜCK, HUGO. 1924. Biologische und Morphologische Untersuchungen über Wasser- und Sumpfgewächse. Vierter Teil: Untergetauchte und Schwimmblattflora. Verlag von Gustav Fischer, Jena. 746 pp. + pls. I–VII.

GOEBEL, K. 1892. Pflanzenbiologische Schilderungen. Zweiter Teil. N. G. Elwertsche Verlagsbuchhandlung, Marburg. pp. 161–386 + pls. XXVI–XXXI.

HARMAN, WILLARD N. 1974. Phenology and physiognomy of the hydrophyte community in Otsego Lake, N.Y. Rhodora **76:** 497–508.

HUTCHINSON, C. EVELYN. 1975. A treatise on limnology. Volume III Limnological Botany. John Wiley & Sons, New York. 660 pp.

LAWRENCE, GEORGE H. M. 1951. Najadaceae, pp. 378, 379. *In:* Taxonomy of vascular plants. The Macmillan Co., New York. 823 pp.

MCDONALD, ELIZABETH SETON. 1937. The life-forms of the flowering plants of Indiana. Am. Midl. Nat. **18:** 687–773.

MOORE, EMMELINE. 1915. The potamogetons in relation to pond culture. Bull. U.S. Bur. Fisheries **33:** 251–291 + pls. XXII–XXXIX.

MUENSCHER, WALTER CONRAD. 1944. Aquatic plants of the United States. Comstock Publishing Co., Ithaca, New York. 374 pp. (Reprinted 1948, 1964, 1967.)

PEARL, RAYMOND. 1907. Variation and differentiation in *Ceratophyllum*. Publ. No. 58. Carnegie Institution of Washington, Washington, D.C. 136 pp.

RICH, PETER H., & ROBERT G. WETZEL. 1969. A simple, sensitive underwater photometer. Limnology & Oceanography **14:** 611–613.

ROSENDAHL, C. O. 1939. Additional notes on *Najas* in Minnesota. Rhodora **41:** 187–189.

ROSS, MARGARET A. 1974. A comparison of the algal floras as related to selected environmental parameters of five artificial ponds of the Delaware, Ohio, Reservoir Wildlife Area. M. S. Thesis, The Ohio State University, Columbus. 80 pp.

SCULTHORPE, C. D. 1967. The biology of aquatic vascular plants. Edward Arnold Ltd., London. 610 pp.

STANLEY, R. A., EDWARD SHACKELFORD, DONALD WADE, & CARRIE WARREN. 1976. Effects of season and water depth on Eurasian Watermilfoil. Jour. Aquatic Plant Management **14:** 32–36.

WAISEL, YOAV. 1971. Seasonal activity and reproductive behaviour of some submersed hydrophytes in Israel. Hidrobiologia **12:** 219–227.

DEPARTMENT OF BOTANY
COLLEGE OF BIOLOGICAL SCIENCES
THE OHIO STATE UNIVERSITY
COLUMBUS, OHIO 43210